C L A I M S

1. A system for mixing a process gas flow that is flowing through a housing (92) of a kiln system (20), said system comprising:

at least one injector (84,86) provided to said housing (94);

a gas supply system (102) connected to said at least one injector (84,86) for supplying injection gas to said injector (84,86) at a predetermined pressure; and

wherein said injector (84,86) and said predetermined pressure are arranged and selected to inject said injection gas into the housing (92) at sufficiently high momentum to produce a jet having the appropriate turbulent flow characteristics such that the process gas flow is entrained by said injected gas.

2. A system for mixing a process gas flow that is flowing through a housing (92) along an axis of said housing (92), said system comprising:

an injector (84,86) provided in said housing (92) and approximately on said axis and directed in the direction of process gas flow;

a gas supply system (102) connected to said injector (84,86) for supplying injection gas to said injector (84,86) at a predetermined pressure; and

wherein said injector (84,86) and said predetermined pressure are arranged and selected to inject said injection gas into the housing (92) at sufficiently high momentum to produce a jet having the appropriate turbulent flow characteristics such that the process gas flow is entrained by said injected gas.

3. A system according to either of claims 1 or 2, wherein said injector (84,86) is provided with swirling means for providing axial swirl to said injected gas.

4. A system according to claim 3, wherein said swirling means comprises swirl vanes (100).

5. A system according to claim 4, wherein said swirl vanes (100) have an angle of approximately 10 to 35 degrees.

6. A system according to any of claims 1 to 5, wherein said injector (84,86) is provided with flare diffusers to enhance said entrainment.

7. A system according to any of claims 1 to 5, wherein said injector is provided with a bluff body to enhance said entrainment.

8. A system according to any of claims 1 to 5, wherein said injector is provided with a bluff body and flare diffusers to enhance said entrainment.

9. A system according to either of claims 6 or 8, wherein said flare diffusers are at approximately 5 to 20 degree half angles.

10. A system according to any prior claim, wherein said process gas flow is substantially entrained before the injected gas flow is converted to plug flow along with the process gas flow or before the injected gas flow impinges upon the interior of the housing (92).

11. A system for mixing a process gas flow that is flowing through a housing (92) along an axis of said housing (92), said system comprising:

a plurality of injectors (84,86) provided to said housing (92) and arranged at predetermined intervals around a cross section of said process gas flow and in communication with the interior of said housing (92); and

a gas supply system (102) for supplying injection gas to said injectors at a predetermined pressure,

wherein said injectors (84,86) are directed to inject said injection gas to impinge tangentially on a circle (98) centered

on said axis of said process gas flow and covering at least approximately 5 to 15 percent of the cross sectional area of said process gas flow.

12. A system according to claim 11, wherein said plurality of injectors (84,86) and said predetermined pressure are arranged and selected to inject said injection gas into the housing (92) at sufficiently high momentum to produce a jet having the appropriate turbulent flow characteristics such that the process gas flow is entrained by the injected gas.

13. A system according to claim 12, wherein said process gas flow is substantially entrained before the injected gas flow is converted to plug flow along with the process gas flow or before the injected gas flow impinges upon the interior of the housing (92).

14. A system according to either of claims 11 or 12, wherein said circle (98) covers at least approximately 5 percent of the cross sectional area of said housing (92).

15. A system according to either of claims 11 or 12, wherein said circle (98) covers approximately 10 percent of the cross sectional area of said housing (92).

16. A system according to any of claims 11 to 15, further comprising swirling means provided to said plurality of injectors (84,86).

17. A system according to claim 16, wherein said swirling means comprises swirl vanes (100).

18. A system according to claim 17, wherein said swirl vanes (100) have an angle of approximately 10 to 35 degrees.

19. A system according to any of claims 11 to 18, wherein said injectors (84,86) are provided with flare diffusers.

20. A system according to any of claims 11 to 18, wherein said injectors (84,86) are provided with bluff bodies.

21. A system according to any of claims 11 to 18, wherein said injectors (84,86) are provided with bluff bodies and flare diffusers.

22. A system according to either of claims 19 or 21, wherein said flare diffusers are at approximately 5 to 20 degree half angles.

23. A system according to any of claims 11 to 22, wherein said plurality of injectors (86) are directed at an angle of approximately 0 to 60 degrees in the direction of process gas flow.

24. A system according to claim 23, wherein said plurality of injectors (86) are directed at an angle of approximately 25 to 40 degrees in the direction of process gas flow.

25. A system according to any of claims 11 to 24, wherein said plurality of injectors (86) comprise a first set of injectors (86) and said system further comprises a second set of injectors (103) comprising:

at least one injector (103) provided to said housing, arranged at a second cross section of said housing (92) and in communication with the interior of said housing (92), and

a second gas supply system for supplying injection gas to said at least one injector (103) at a predetermined pressure,

wherein said at least one injector (103) is directed to inject gas to impinge tangentially on a second circle (104) centered on said axis of said housing (92) that has a different diameter than the circle (98) of said first set (86) of injectors.

26. A system according to claim 25, wherein said second circle (104) has a larger diameter than said circle (88).

27. A system according to either of claims 25 or 26, wherein said second cross section of said housing (92) is spaced apart from said cross section of said first set of injectors (86) in the direction of process gas flow.

28. A system according to claim 25, wherein said gas supply system (102) for said first set of injectors further comprises said second gas supply system.

29. A system according to any prior claim, wherein said injected gas is air or oxygenated air.

30. A system according to any prior claim, wherein said injected gases may be preheated.

31. A system according to any prior claim, wherein said kiln system (20) is for preparing cement clinker and said system is in a region of said kiln system (20) where the gas temperature is between approximately 850 to 1400 degrees Celsius.

32. A system according to claim 31, wherein said gas temperature is between approximately 1000 to 1250 degrees Celsius.

33. A system according to any prior claim, wherein said housing (92) is a housing of a rotary kiln (42).

34. A system according to any of claims 1 to 32, wherein said housing (92) is a housing of an exhaust gas by-pass system.

35. A system according to claims 1 to 32, wherein said housing (92) is a housing of a precalciner.

36. A system according to any of claims 1 to 31, wherein said housing (92) is a housing of a a gas riser duct (34).

37. A system according to any of claims 1 to 31, wherein said housing (92) is a housing of a precalciner in a region near a gas exit where said gas temperature is between approximately 900 to 1250 degrees Celsius.

38. A system according to any of claims 1 to 31, wherein said housing (92) is a housing of said kiln system (20) in a region in which said system will enhance the efficiency and completion of reactions with ammonia where said gas temperature is between approximately 850 to 1050 degrees Celsius.

39. A method of mixing a process gas flow of a kiln system comprising:

providing a source of injection gas at high pressure; and

injecting said injection gas into said process gas flow via at least one injector at sufficiently high momentum to produce a jet having appropriate turbulent flow characteristics such that the process gas flow is entrained by the injected gas.

40. A method of mixing a process gas flow according to claim 39, further comprising imparting swirl to said injected gas as it enters the housing.

41. A method of mixing a process gas flow according to claim 40, wherein said swirl is imparted by swirl vanes provided to said at least one injector.

42. A method of mixing a process gas flow according to any of claims 39 to 41, wherein said entrainment is further enhanced by a bluff body provided to said at least one injector.

43. A method of mixing a process gas flow according to any of claims 39 to 41, wherein said entrainment is further enhanced by a flare diffuser provided to said at least one injector.

44. A system according to any of claims 39 to 41, wherein said entrainment is further enhanced by a bluff body and a flare diffuser provided to said at least one injector.

45. A method of mixing a process gas flow according to any of claims 39 to 44, wherein the total momentum of said injected gas during injection is approximately 50 to 150% of the momentum of said process gas flow.

46. A method of mixing a process gas flow according to any of claims 39 to 45, wherein said injected gas is injected at or above approximately 150 meters/second.

47. A method of mixing a process gas flow in a housing of a kiln system comprising:

providing a source of injection gas at high pressure; and

injecting said injection gas into said housing via at least one injector such that said injection gas impinges tangentially on a circle centered on said axis of said process gas flow and covering at least approximately 5 to 15 percent of the cross sectional area of said process gas flow.

48. A method of mixing a process gas flow according to claim 47, wherein said injecting of said injection gas into said process gas flow is at sufficiently high momentum to produce a jet having appropriate turbulent flow characteristics such that the process gas flow is entrained by the injected gas.

49. A method of mixing a process gas flow according to either of claims 47 or 48, further comprising imparting swirl to said injection gas as it enters the housing.

50. A method of mixing a process gas flow according to claim 48, wherein said swirl is imparted by swirl vanes provided to said at least one injector.

51. A method of mixing a process gas flow according to any of claims 48 to 50, wherein said entrainment is further enhanced by a bluff body provided said at least one injector.

52. A method of mixing a process gas flow according to any of claims 48 to 50, wherein said entrainment is further enhanced by a flare diffuser provided to said at least one injector.

53. A method of mixing a process gas flow according to any of claims 48 to 50, wherein said entrainment is further enhanced by a bluff body and a flare diffuser provided to said at least one injector.

54. A method of mixing a process gas flow according to any of claims 48 to 53, wherein the total momentum of said injection gas during injection is approximately 50 to 150% of the momentum of said process gas flow.

55. A method of mixing a process gas flow according to any of claims 47 to 54, wherein said injection gas is injected at or above approximately 150 meters/second.

56. A method of mixing a process gas flow of a kiln system according to claim 47, wherein the Reynolds Number due to said mixing is approximately 2.5 times above that encountered in the typical process gas flow without said mixing.

57. A method of mixing a process gas flow of a kiln system according to claim 47, wherein the turbulent frequency due to said mixing is approximately 100 times above that encountered in the typical process gas flow without mixing.

58. A method of mixing a process gas flow of a kiln system according to claim 47, wherein a total momentum, turbulence and swirl of said injected gas are selected based on aerodynamic calculation such that said injected gas will substantially entrain the whole of said process gas flow before the injected gas flow is converted to plug flow along with the process gas flow or before the injected gas flow impinges upon the interior of the housing.

59. A method of mixing a process gas flow of a kiln system according to claim 47, wherein a total momentum, turbulence and swirl of said injected gas are selected based on mathematical modelling such that said injected gas will substantially entrain the whole of said process gas flow before the injected gas flow is converted to plug flow along with the process gas flow or before the injected gas flow impinges upon the interior of the housing.

60. A rotary kiln of a kiln system provided with a system for mixing a process gas flow according to any of claims 1 to 32.

61. A precalciner of a kiln system provided with a system for mixing a process gas flow according to any of claims 1 to 32.

62. An exhaust has by-pass system of a kiln system provided with a system for mixing a process gas flow according to any of claims 1 to 32.

63. A preheater section of a kiln system provided with a system for mixing a process gas flow according to any of claims 1 to 31.

64. A gas riser duct of a kiln system provided with a system for mixing a process gas flow according to any of claims 1 to 31.